Popular Summary

Variable retention in a sub-boreal landscape: Is it worth the hassle?

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Presentation Abstract

Stand-level studies have shown partial cutting (typically 30–70% canopy retention) maintains habitat for many species using mature forest. We used simulation modelling to examine the potential magnitude of such benefits if a shift to 30% of harvest volume from clearcutting to partial cutting was implemented in the Nadina Forest District, in the context of mountain pine beetle attack, salvage harvesting, and climate change. We projected future landscape conditions by applying 140-year harvest trajectories from Timber Supply Review simulations to four retention scenarios: (1) "status quo" of no retention beyond conventional wildlife-tree-patch requirements; (2) retention of understorey conifers; (3) retention of 30–70% of live overstorey; and (4) both understorey and overstorey retention.

We then assessed the ability of projected landscapes to support wildlife species "profiles" representing territory size requirement and strength of association with mid- to old-seral forests. We focussed on species generally associated with mid- to old-seral forests and constrained in their use of space by territoriality (e.g., marten). For each landscape, we estimated the number and quality of potential territories, and dispersal connectivity among territories. We also projected mature-forest bird community similarity.

Retention strategies led to substantive increases (10–38%) in long-term territory abundance and bird community similarity. Depending on species profile, overstorey retention had the greatest long-term effect: ~5–26% above status quo for territory abundance, and 0–7% with understorey retention alone. Connectivity differences were more equivocal. Increased territory abundance in turn made populations more resilient to increased future disturbance risk from changing climate.

KEYWORDS: *climate change, mountain pine beetle, partial cutting, sub-boreal landscapes, variable retention, wildlife habitat.*

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Background

Overstorey retention via partial cutting has been proposed to maintain mature-forest habitat for wildlife while allowing extraction of timber (e.g., Waterhouse *et al.* 2007). We used simulation modelling to explore the potential magnitude of such benefits if a shift of 30% of harvest volume from clearcutting to partial cutting was implemented in the Nadina Forest District. This was applied in the context of extensive mountain pine beetle attack, accelerated salvage harvesting, and disturbance risk from climate change.

For a net gain at the landscape scale, the stand-level habitat benefit must be, on average, greater than the stand-level canopy proportion retained. Otherwise, the benefits would be offset by increased area harvested or more frequent harvest entries. The response to percentage retention, however, varies among species (Huggard 2006), which argues for maintaining a variety of retention levels.

A second type of retention we consider is protection of advanced regeneration or understorey. Presence of understorey provides structural diversity within mature forests, and aids recovery from overstorey removal or mortality. Currently, such understorey is usually removed in favour of regeneration by planting.

Wide-ranging territorial species that favour mature forest may be particularly sensitive to habitat loss; they need to integrate sufficient area of suitable habitat to create effective territories (e.g., marten; Hargis *et al.* 1999). Sparse habitat may be offset by expanded territory size, but size is limited by energetic cost. If sparse habitat in turn leads to widely dispersed territories, dispersal among territories may also be affected. A greater amount of habitat on the landscape, as from application of retention, could allow greater flexibility in the spatial use of habitat.

Using simulation experiments, we explored some district-scale implications through time (140 years) of the above assumptions.

Landscape Model

We used the SELES (Spatially Explicit Landscape Event Simulator) domain language and simulation engine (Fall and Fall 2001). We started with maps of the current condition of the study area (circa 2000), including biogeoclimatic subzones, forest age, site index, etc. There were no maps of understorey structure; thus, we applied hypothetical maps using the proportions reported by Coates *et al.* (2006).

We then simulated the predicted spread of beetle-attack, and applied timber harvesting "rules" representing management strategies. Harvest targets, in clearcut equivalent hectares, were set consistent with B.C. Ministry of Forests and Range Timber Supply Review projections, including increased harvesting to address the beetle infestation.

We simulated four harvesting policies.

1. Clearcut and plant: Harvesting removes all trees except for wildlife tree patches and establishes a new stand of age zero, assuming planting.
2. Clearcut and retain understorey: Same as (1), but retains understorey conifers if present. Stand age reflects the clearcut-equivalent-age (Coates *et al.* 2006) of advanced regeneration (0 to 60 yrs).
3. Partial cut and plant: 30% of the target harvest volume was applied as partial cutting, and the remaining 70% as clearcutting. For each partial cut harvest block, an overstorey retention target was chosen from the range of 30–70%. Harvestable volume had to exceed 30% prior to entry. The harvested portion of the stand was re-established to age zero, assuming planting.
4. Partial cut and retain understorey: Same as (3), but also retained understorey.

We repeated the scenarios with stochastic natural disturbance at 30% and 50% of mean estimated historic rates (Steventon 2001). For each rate, we also simulated the spread of higher disturbance subzones into lower disturbance subzones as predicted with climate change. Disturbance events removed 90% of the stand-level overstorey in patches ranging from 20 to 2000 ha. Each disturbance scenario was repeated five times to account for variability.

Wildlife Response Model

The first step was to assign every 1-ha cell on the landscape a score from 0 to 1 representing potential habitat value. The landscape model tracked two live-tree canopy layers (overstorey and understorey). The base habitat value of each layer followed a sigmoidal relationship with stand age of the form $[1-\exp(-10(\text{age}/\text{opt\_age})^5)]$, where age is the time since disturbance and opt_age is the age after which there is no further improvement in habitat recovery (60, 120, or 180 years). The effective "ages" of both tree layers were adjusted by site index (productive sites recovered more quickly as habitat).

For beetle-killed stands or with partial cutting, the base habitat value was adjusted for the proportion of remaining live overstorey. First, we applied the bird community similarity response curve of Huggard (2006, Figure 7b). We considered this a "coarse-filter" indicator, integrating a number of species response profiles to retention level. Second, we applied the sigmoidal relationship $[\exp(-8(p^{2.5})]$ where $1-p$ is the proportion of the canopy retained. This represented species where, as overstorey was removed, habitat value initially remained high, followed by an exponential decline with continued removal. We also assumed that beetle-killed trees contribute to habitat value for a short period. The value of beetle-killed trees declined exponentially through time $[\exp(-7.5(\text{years}/20)^5)]$ approaching 0 after 20 years.

The same equations used to determine the habitat value of the overstorey were applied to the understorey. The final raster cell score was the sum of the live overstorey, dead overstorey, and understorey values (to the maximum score of 1).

We then delineated potential territories for the sigmoidal habitat response profile, applying three minimum territory sizes (25, 250, and 2500 ha). Territories could expand up to three times the minimum size to capture sufficient resources, with final territory quality calculated as the inverse of territory size assuming larger territories entail a higher energetic cost. We report territory numbers weighted by the quality score.

We assessed dispersal connectivity among territories using a landscape graph approach similar to O'Brien *et al.* (2006) that estimated the proportion of territories within dispersal range (adjusted for movement cost, and probability of dispersing various distances).

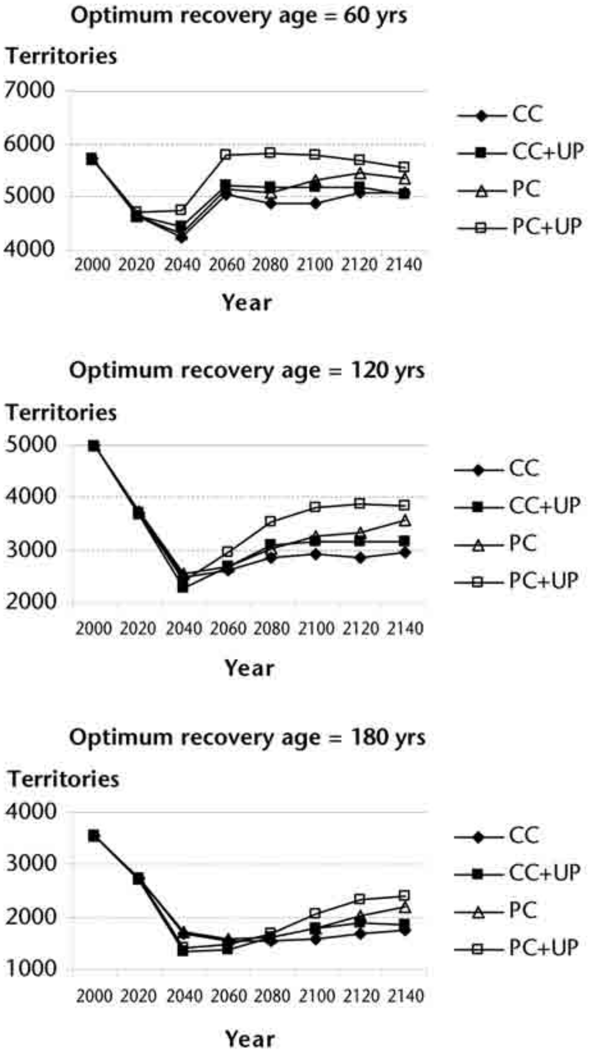

FIGURE 1. Predicted territory abundance by management strategy (CC = clearcutting only; CC+UP = clearcutting with understorey protection; PC = partial cutting; PC+UP = partial cutting and understorey protection) for three habitat recovery assumptions (optimum recovery ages of 60, 120, and 180 years).

Results

The predicted number of territories decreased in proportion to territory size (i.e., minimum). Territory size did not interact with harvesting policy, thus we only report on the 250-ha territory scale (approximating female marten).

In the absence of future natural disturbance, partial cutting in combination with understorey retention was the most effective habitat strategy (Figure 1). It facilitated a more rapid and higher recovery from the beetle mortality and salvage era. At the end of the simulation period, it provided 10–38% (depending on habitat recovery assumptions) more potential territories than did "status quo" clearcutting. Understorey retention alone provided a 0–7% increase, partial cutting a 5–26% increase. The influence of understorey retention was greatest in the mid-term, while the influence of overstorey retention was greatest later in the simulations. Connectivity among territories did not show any strong differences among the scenarios. Bird community similarity showed patterns of response similar to territory abundance.

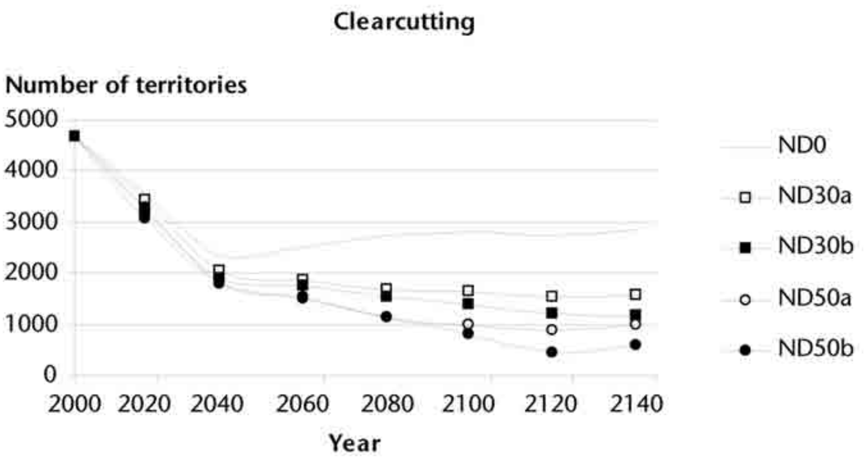

FIGURE 2. Total number of territories for clearcutting and partial cutting policies with varying rates of natural disturbance: ND means natural disturbance and is followed by the rate (%); "a" means no subzone spread; "b" means subzone spread. Optimum recovery age of 120 years.

With the addition of future natural disturbance, the relative benefits of retention followed the same general pattern as above. Partial cutting in combination with understorey retention remained the most effective habitat strategy. At the end of year 2075 (prior to significant harvest deficits that complicate interpretation), it provided about the same absolute increase in territory abundance (ranging from 715 to 826 territories) for all but the most extreme disturbance scenario (ND50b). This absolute increase translated into higher percentage increases over clearcutting (from 28 to 64% depending on disturbance rate). Again, bird community similarity showed similar patterns of response as territory abundance.

Natural disturbance caused similar proportional declines in territory abundance for all harvest policies (Figure 2). Territories reached a minimum shortly after the beetle outbreak and related salvage (at about 2035). With minimal post-beetle disturbance (ND0), habitat increased until about 2075 and then stabilized. Increased future disturbance coupled with harvesting brought habitat abundance to lower equilibriums, never recovering to levels found before the beetle outbreak.

In addition to reducing old forest habitat, increased natural disturbance rates reduced the area harvested. Partial cutting without understorey retention led to the highest harvest deficits in all scenarios. In most cases, policies that retained understorey had the lowest deficits. Shortfalls in harvest usually became apparent after 2075.

Discussion

We are continuing to refine both the landscape dynamics model and the breadth of our wildlife response assumptions. While we believe the pattern of model outcomes we present to be robust, the results should be considered preliminary. Retention strategies substantially improved habitat outcomes in all scenarios. However, there has been resistance to partial cutting in the central/northern interior of British Columbia. This resistance likely stems from questions around perceived loss of timber production, and increased cost and complexity.

If variable retention treatments can realize similar timber productivity over time as do clearcuts, then habitat benefits accrue without reducing timber supply. Silviculturists, however, are still debating the volume production implications of partial cutting versus clearcutting. In our future disturbance scenarios, partial cutting resulted in higher harvest deficits due to constraints on area available (not productivity). Modifying our harvest rules to allow more flexibility in harvesting rate and strategy among time periods could reduce the deficit, and needs to be better explored. The increased cost of partial cutting, however, is likely the main short-term impediment to application.

Potential negative conservation effects of partial cutting are increased road density and reductions in snag abundance. The magnitude and significance of these effects, however, is dependent on many factors (Bütler *et al.* 2004; Delong *et al.* 2004).

Overall, we conclude that empirical evidence and simulation experiments support the conservation value of variable retention as part of a landscape strategy in sub-boreal forests. In earlier simulation experiments we found the only other effective conservation tool was reduced mid- to long-term harvest rates. However, if variable retention is to be useful at a population scale and not just an interesting curiosity, it will have to be applied thoughtfully and over a substantive portion of the harvested land base. We suggest starting in targeted watersheds to allow testing of landscape-scale predictions.

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